Ministry
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Ontario

MI-150

The Waste Tire Paving Demonstration Project at Thamesville, Ontario

MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

TECHNICAL REPORT DOCUMENTATION PAGE

The Waste Tire Paving Demonstration Project at Thamesville, Ontario

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Abstract:

Ontario generates over 10 million waste passenger tire equivalents per year. Some are reused but the majority go into the waste stream. In support of the Ontario Ministry of the Environment's efforts to dispose of waste tires, the Ministry of Transportation, Ontario built a demonstration hot mix pavement incorporating waste tire rubber at Thamesville in 1990.

The purpose of the demonstration was to confirm that

(a) the construction of asphalt rubber hot mix pavements is environmentally acceptable and complies with worker health and safety regulations,
(b) pavement containing asphalt rubber hot mix can be recycled in both the plant mix and in place modes,
(c) pavements containing asphalt rubber hot mix provide equivalent performance to standard pavements.

The work consisted of 6.5 km each of asphalt rubber mix and standard mix. Both mixes were produced in a drum plant and placed with conventional paving equipment. The rubber content of the mix was 2.0%.

A full schedule of stack testing was carried out to determine the presence and level of a wide variety of pollutants. Testing was also carried out at the mixing and placing operations to confirm that the process was in compliance with all Ontario worker health and safety regulations.

A description of the work, a preliminary performance evaluation, a discussion on the findings of the environmental and worker safety testing and a costing analysis are included in the paper.

Keywords: Asphalt Rubber; Waste Tires; Thamesville

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THE WASTE TIRE PAVING DEMONSTRATION PROJECT AT THAMESVILLE, ONTARIO

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THE WASTE TIRE PAVING DEMONSTRATION PROJECT AT THAMESVILLE, ONTARIO

BACKGROUND

Ontario drivers generate the equivalent of twelve million scrap passenger tires every year. The tires represent a serious disposal problem. When placed in landfills they are difficult to stabilize, they fill with water and breed mosquitoes, and they are a constant fire hazard. At present, approximately 10 per cent of the used tires are sold overseas for reuse or are recycled for products such as carpet backing. It is possible that the remainder could be used as fuel for industries such as cement manufacturing, however, it is obviously preferable to recycle as large a proportion of the tires as possible. The use of tire rubber in hot mix asphaltic concrete offers the possibility of recycling a much higher percentage of the total numbers of scrap tires generated.

In the past the Ontario, Ministry of Transportation had experimented with recycling about 1 per cent of fine tire rubber in hot mix. The resulting product had not performed well. In 1989, the Ministry of the Environment approached the Ministry of Transportation to try out a new system using up to 3 per cent of tire rubber as aggregate replacement. Preliminary reports from other authorities had indicated a better chance of success with this method, plus the opportunity to dispose of large quantities of tires was extremely attractive. Because the aggregate replacement system is fairly new and there was no information on environmental impacts, worker safety, and long term performance, it was agreed that a major trial of asphalt rubber hot mix should be built to assess the viability and acceptability of this method of tire recycling.

On February 19th, 1990 the Hagersville tire fire started and burned for 17 days. This major environmental disaster gave added impetus to efforts to solve the tire disposal problem.

OBJECTIVES OF THE TRIAL

The objectives of the trial were:

a) to evaluate the technical aspects of mixing and placing asphalt rubber mix containing 3 per cent of coarse rubber;

b) to mix the material in an oil-fired drum mix plant, since this type of hot mix plant is used on most Ministry work outside of major urban areas;

c) to obtain exhaust stack air quality measurements for comparison with the regulatory standards;

d) to carry out "Air Quality Assessment" testing for compliance with worker health and safety regulations;

e) to establish the recyclability of asphalt rubber mixtures using a drum mix plant;

f) to test asphalt rubber mix for compliance with waste disposal regulations;

g) to evaluate the performance of the asphalt rubber mix at high (3 per cent) rubber contents;

h) to determine the viability of using the hot in-place surface recycling process on asphalt rubber pavements, and its compliance with environmental and worker safety regulations; and

i) to obtain reasonably accurate estimates for the cost of asphalt rubber mix.

LAYOUT OF THE TRIAL

The length of the trial was controlled by three factors:

a) the need to mix and place sufficient standard mix to establish a baseline of environmental and worker safety testing values and provide a control section for future performance evaluation;

b) the need to accommodate three construction processes i.e. asphalt rubber mix, recycled asphalt rubber mix and surface recycling; and

c) sufficient plant operating time for each stack test (6 hours) and for the number of stack tests (three per mix type) required to inspire confidence in the data.

This added up to a total length of 12 km using 6,000 tonnes each of asphalt rubber mix and standard mix.

It would have been desirable to carry out all three construction processes in the construction season (May to September, 1990) but this was not possible so the recycling processes were deferred to 1991.

LOCATION OF THE TRIAL

Two suitable locations for the work were identified in South Western Ontario and were offered as options in the construction tender. The successful bidder - Huron Construction Ltd. of Chatham - chose the Thamesville site on Hwy. #2, 22 km east of Chatham (see Figure 1).

Highway #2 at Thamesville is a two lane rural highway. The terrain is flat and the alignment generally follows the Thames River. The subsoil is chiefly Berrien sand, Gilford gravelly loam and Thames clay loam. Traffic volumes are 2050 to 2750 AADT and 2250 to 3050 SADT with 9 per cent to 10 per cent trucks. The surrounding land use is farming.

The existing pavement was in very good structural condition with a fair ride. The hot mix surface was suffering from slight ravelling in areas of segregation, and there was extensive minor reflection cracking which had been crack filled.

The 7.5 metre wide pavement consisted of 130 mm of dense graded hot mix over 230 mm of concrete pavement. The concrete pavement had been built in the 1920's. The first hot mix surfacing was placed in 1955 and was resurfaced with recycled hot mix in 1982.

CONTRACT DETAILS

The work carried out in 1990 involved placing 50 mm of hot mix over a tackcoat. The standard mix was a minus 19 mm dense graded mix (MTO Designation HL4 or Asphalt Institute Mix Type IV b). The asphalt rubber mix was HL4 mix with 3 per cent rubber and an additional 1.5 per cent asphalt cement. The tackcoat was diluted SS1 asphalt emulsion applied at 0.35 kg/m^2.

MIX DESIGN

The standard mix proposed by the contractor used a crushed gravel coarse aggregate and natural fine aggregate. It was found that this mix could not accommodate the 3 per cent rubber requirement. To increase the percentage of rubber which could be used, the crushed gravel was replaced with a quarried limestone, and 80 per cent of the fine aggregate was replaced with another gravel aggregate of a finer gradation. However, even with these adjustments, the maximum rubber which could be placed in the mix was about 2 per cent. The replacement aggregates were used in the standard mix also.

The final mix design selected for the standard and asphalt rubber mixtures is summarized in Table 1.

Table 1. Mix Design

	Standard	Asphalt Rubber
Job Mix Formula		
% Asphalt Cement	5.3	6.1
% Coarse Aggregate		
(Quarried HL4 Stone)	44.5	49.0
% Fine Aggregate		
(Huron Const. Asp. Sand)	45.5	42.0
(Oxford Sand)	10.0	7.0
% Crumb Rubber		2.0
Marshall Properties		
% Air Voids	4.0	4.0
Flow (0.25mm)	10.5	18.8
Stability (N)	10800.0	5250.0
% VMA	14.0	17.0
Compacted Specific Gravity	2.445	2.337
Maximum Relative Density	2.506	2.418

It is interesting to note that the addition of coarse scrap rubber to dense graded hot mix has the effect of raising the flow value and lowering the stability values, with the flow value increased by almost 80 per cent and the stability value lowered by over 50 per cent. What this means in terms of pavement performance is not yet clear. In any case the accepted Marshall criteria probably cannot be applied directly to asphalt rubber mixes. The stability value for the asphalt rubber mix used at Thamesville was below the minimum specified value for standard mix (5250 vs 6700 Newtons) but this was deemed acceptable on the advice of the Ministry's consultant. The mix design charts and mix design gradations are provided in Figures 2 to 5. The asphalt cement data is shown in Table 2.

Table 2. Asphalt Cement Data

Penetration @ 25°C, 100G, 5 SEC, 0.1 mm	85
Kinematic Viscosity @ 135°C, mm ^{2}/s	312.1
Ductility @ 48c, 1 cm/min, cm	115
Absolute Viscosity@ 60°C, Poise	1431.9

CONSTRUCTION PROBLEMS

The gradation of the rubber supplied to the work was coarser than specified, as shown in Table 3.

Table 3. Gradation of Rubber

	% PASSING	
Sieve Size	**Specification**	**Product**
4	100	98.8
8	70-80	59.8
10	50-60	48.4
20	30-40	24.9
40	5-15	6.6

As the project was behind schedule when the rubber was delivered to the site, it was decided to proceed with the off-specification rubber.

The paving train for the standard mix consisted of a vibratory breakdown roller, a rubber-tired intermediate roller and a steel-wheeled finishing roller. Based on the experiences of others, the contract documents had stipulated that a rubber-tired roller was not to be used with the asphalt rubber mix; however, it was found necessary to use a rubber-tired roller to roll out the very severe checking caused by the breakdown roller. To minimize pick-up with the rubber-tired roller rolling was delayed with the

result that the density of the asphalt rubber mix averaged 93 per cent vs 97.0 per cent for the standard mix.

Apart from the above, no other problems were encountered in the work. Paving commenced on September 22nd and ended on October 16th with some lost time due to rain.

AIR EMISSIONS FROM HOT MIX PRODUCTION

During hot mix production the Ontario Ministry of the Environment (MOE) and Ortech International, a testing company, conducted testing of the stack emissions from the conventional and rubber mixes. The test results are given in Table 4.

The major air quality problem on this contract was the level of particulate matter. For conventional hot mix the maximum levels exceeded air quality standards by about 30 to 40 per cent and for the rubber mix the maximum levels were 4 to 5 times higher than the air quality standards.

The MOE has commonly been allowing benzene emissions of up to a total of 800 grams per year from any one source. This project alone, based on the emission rates measured, released 1.5 times this limit. To date, however, no determination has been made regarding an allowable level for this type of project.

The point of impact values in Table 4 are worst case values. No other emissions measured exceeded MOE standards even in worst case conditions. The particulate and benzene emissions could probably be reduced on future projects by use of alternative fuels in the plant or by improved emission control procedures or equipment.

PLANT WASTES

The waste water generated by the air emission control equipment at the plant was tested and compared with provincial objectives. The test results are shown in Table 5. The water quality was not suitable for disposal in storm systems, but apart from the level of manganese which exceeded current guidelines by 40 per cent, the water was suitable for discharge into sanitary sewers.

Samples of asphalt pavement, rubberized pavement, rubber and the sludge from the air emissions control equipment were tested with respect to Ontario's Regulation 309 Leachate Quality Criteria for leachable metals and benzo-a-pyrene. The levels did not exceed current criteria and it appears the materials could be disposed in normal sanitary landfills.

WORKER SAFETY TESTING

Air quality sampling was conducted in the vicinity of workers at the hot mix plant and the paving site. Tests were conducted for a variety of metals, particulates, selected volatile organic compounds and heavier organic compounds. The only exposure problems of concern which were identified were particulate levels during production of the rubberized mix. One test was 1.6 times the current established maximum level. For conventional asphalt the particulate level was only 0.1 times the standard.

Particulate levels were also higher for the rubberized mix at the paving site. The test results are listed in Table 6.

Tables 4, 5 and 6 were produced for the Ministry of Transportation by Trow, Dames and Moore through a contract with Trow Consulting Engineers. The discussion above is based on preliminary information provided by Trow, Dames and Moore. The conclusions and recommendations of their preliminary report are as follows:

From an environmental and occupational health and safety perspective, the production and lay down of asphalt pavement and more specifically rubberized asphalt pavement has the potential for some problems. These problems include air emissions and occupational airborne contaminant exposure. These are problems for which solutions do exist. Based on testing to date, with proper management of these currently identified areas of concern, this work can be conducted within the bounds of current legislation. The use of natural gas as firing fuel for the plant process may decrease both particulate and benzene emissions levels. Strict process control and in depth maintenance of emissions control equipment can also help to reduce maximum emission rates. Further testing of environmental and occupational health and safety parameters is recommended in subsequent project phases to confirm results to date, to document further areas of interest identified by this study and to document emission and exposure levels during the added activities planned.

PERFORMANCE TO DATE

The standard mix is performing well at this time. The asphalt rubber mix is performing well apart from three concerns:

a) Some large coarse aggregate particles are being dislodged from the surface wherever a particle of rubber is immediately under the aggregate. The occurrence of this phenomenon is variable and ranges from zero per square metre to 100 per square metre.

b) The longitudinal construction joint at centreline is showing some joint opening and raveling; and

c) The mat is more permeable and is slow to dry out after rain.

COSTS

The additional cost for the asphalt rubber mix at Thamesville was -

Rubber @ $370.00/t @ 2%	=	$7.40
Asphalt Cement @ $200.00/t @ 0.8%	=	$1.60
Handling	=	$1.40
Aggregate upgrading	=	$2.60
		$13.00/t

For non-experimental work, the typical price for HL 4 mix in 1990 in Southern Ontario was $35.00 per tonne. Hence asphalt rubber mix is approximately 37 per cent more expensive than standard mix. This does not include the cost of $100,000.00 of modifications to the hot mix plant as it is not reasonable to attach all of these costs to this work alone.

FUTURE WORK

For 1991, sections of both mix types will be recycled in a drum mix plant at 35 per cent reclaimed pavement material and 65 per cent new aggregate. New rubber will be added to the asphalt rubber recycled mix to maintain the total rubber content at 2 per cent. Two sections of new asphalt rubber mix are planned, one with rubber to meet the 1990 rubber specification and the other with a finer grade of rubber i.e. 100 per cent passing the #10 sieve. The environmental and safety testing will be continued.

The hot in-place surface recycling has been delayed to 1992 to allow planning of the environmental testing for this technique.

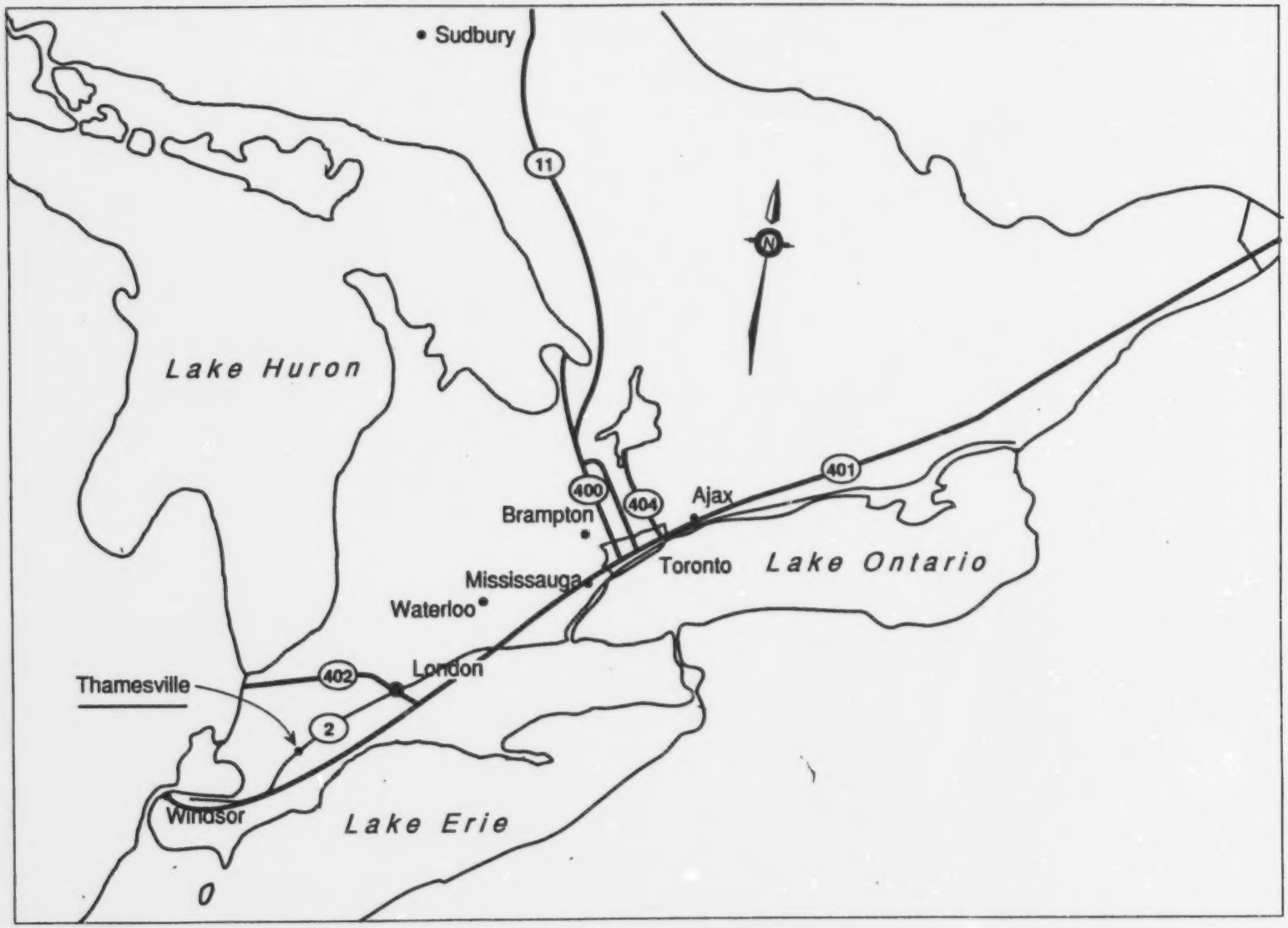

Sudbury
11
N
Lake Huron
400
404
401
Brampton
Ajax
Toronto
Lake Ontario
Mississauga
Waterloo
London
402
Thamesville
2
Windsor
Lake Erie
0

Figure 1

Trow

BITUMINOUS MIX DESIGN REPORT

CONTRACT NO.	90-800	HOT MIX TYPE / USE	HL4	ITEM NO.	
HWY.	2	LOCATION	From East Limit of Thamesville, Easterly 13.5 km		
TESTING LAB.	Trow Geotechnical Ltd.	JOB MIX FORMULA NO. Issued by Qual Assurance			
LAB. MIX NO.	HL4	DATE SAMPLES REC'D.	Sept. 1990		
TEST DATA CERTIFIED BY:	[signature] PAUL PENG	DATE COMPLETED	Sept. 1990		

JOB MIX FORMULA - GRADATION PERCENT PASSING *

% AC	26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75
5.3		100	98.3	91.9	71.3	56.0	47.2	38.6	30.0	18.3	7.5	3.4

MARSHALL	REQUIREMENTS	SELECTED
% VOIDS (min.) (max.)	3.5	4.0
FLOW (min.)	8.0	10.5
STAB. (min.)	6700.0	10800.0
% VMA (min.)	14.5	14.0

% CA # 1	44.5	% RAP	
% CA # 2		% AC RAP	
% FA # 1	45.5	RAP PEN	
% FA # 2	10.0	BRIQ. BRD	2.445
% FA # 3		MRD	2.506
Gb	2.673	MRD (SD)	

ASPHALT CEMENT		ADDITIVE		
SUPPLIER	PENETRATION	SUPPLIER	TYPE	AS % OF AC
McAsphalt	85 - 100			

AGGREGATE TYPE	SOURCE / INVENTORY NO.	AGGREGATE TYPE	SOURCE / INVENTORY NO.
COARSE AGG. # 1	Bedrock HL4 Stone	FINE AGG. # 2	Oxford Sand
COARSE AGG. # 2		FINE AGG. # 3	
FINE AGG. # 1	Huron Construction Asphalt Sand	RAP	

AGGREGATE TYPE	BULK RELATIVE DENSITY	ABSORPTION	AGGREGATE GRADATION - PERCENT PASSING											
			26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75
CA #1	2.700			100.0	97.0	84.5	42.9	5.1	1.4	1.3	1.2	1.2	1.0	0.8
FA #1	2.651						100.0	100.0	99.3	97.6	92.7	71.1	26.1	8.1
FA #2	2.634						100.0	96.2	80.6	62.1	44.3	23.3	9.7	4.9
RAP CA														
RAP FA														

* FINES RETURNED TO THE MIX (%)

REMARKS:

REVIEWED BY: _____ (MTO) DATE: _____

FIGURE 2

Trow Geotechnical Ltd.
1595 Clark Boulevard, Brampton
Ontario, Canada. L6T 4V1
Telephone: (416) 793-9800
Fax: (416) 793-0641

Hot Mix Design by Marshall Method

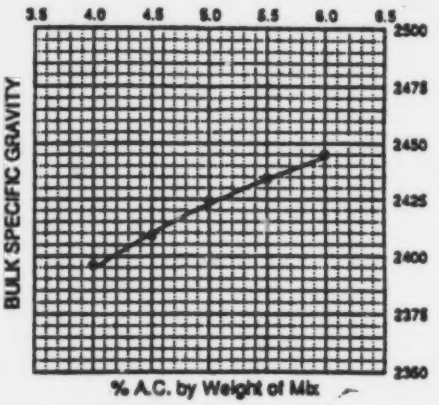
TEST PROPERTY CURVES

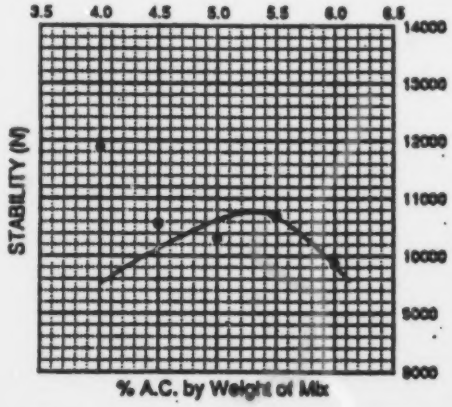
Project Number:

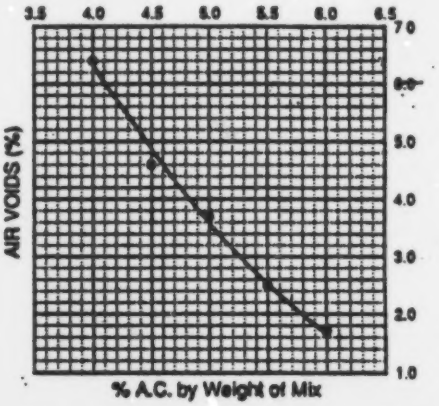
Client: HURON CONSTRUCTON

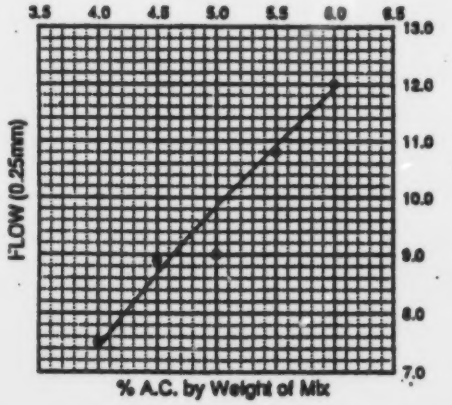
Date: 09/23/90

Type of Mix: HL4









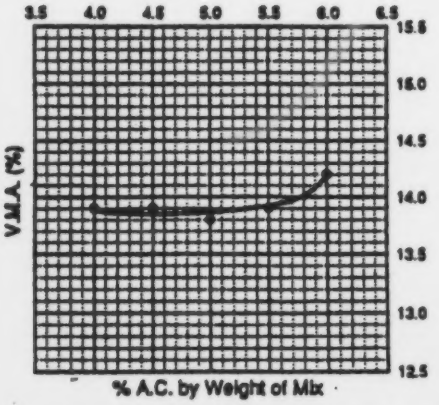


FIGURE 3

Trow

BITUMINOUS MIX DESIGN REPORT

CONTRACT NO	90-800	HOT MIX TYPE / USE	HL4 MOD	ITEM NO	
HWY.	2	LOCATION	From EAST LIMIT OF THAMESVILLE, EASTERLY 13.5 km		
TESTING LAB.	TROW GEOTECHNICAL	JOB MIX FORMULA NO. Issued by Qual Assurance			
LAB. MIX NO.	HL4 RUB	DATE SAMPLES REC'D	SEPT. 1990		
TEST DATA CERTIFIED BY:	P. O'HILLON P.Eng.	DATE COMPLETED	SEPT, 1990		

JOB MIX FORMULA - GRADATION PERCENT PASSING ★

% AC	26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75
6.1		100.0	98.5	92.4	72.0	51.8	43.1	34.8	26.6	15.8	7.0	3.2

MARSHALL	REQUIREMENTS	SELECTED
% VOIDS (min.) (max.)	3 - 5	4
FLOW (mm.)	8	18.8
STAB. (min.)	—	5250
% VMA (mm.)	14.5	17

% CA # 1	49.0
% CA # 2	—
% FA # 1	47.0
% FA # 2	3.0
% FA # 3	2.0
Gb	2.638

% RAP	—
% AC RAP	—
RAP PEN	—
BRIQ. BRD	2.337
MRD	2.418
MRD (SD)	—

ASPHALT CEMENT	
SUPPLIER	PENETRATION
McASPHALT	85-100

ADDITIVE		
SUPPLIER	TYPE	AS % OF AC
—	—	—

AGGREGATE TYPE	SOURCE / INVENTORY NO.	AGGREGATE TYPE	SOURCE / INVENTORY NO.
COARSE AGG. # 1	BEDROCK HL4 STONE	FINE AGG. # 2	OXFORD SAND
COARSE AGG. # 2	/	FINE AGG. # 3	RUBBER
FINE AGG. # 1	HUSKY CONST. ASPHALT SAND	RAP	/

AGGREGATE TYPE	BULK RELATIVE DENSITY	ABSORPTION	AGGREGATE GRADATION - PERCENT PASSING											
			26.5	19.0	16.0	13.2	9.5	4.75	2.36	1.18	600	300	150	75
CA # 1	2.70			100	97.0	84.5	42.9	5.1	1.4	1.3	1.2	1.2	1.0	0.8
FA # 1	2.651						100	100	99.3	97.6	92.7	71.1	26.1	8.1
FA # 2	2.634						100	96.2	80.6	62.1	44.3	23.3	9.7	4.9
FA # 3	1.15									—	—	—	—	—
RAP CA														
RAP FA														

★ FINES RETURNED TO THE MIX (0 %)

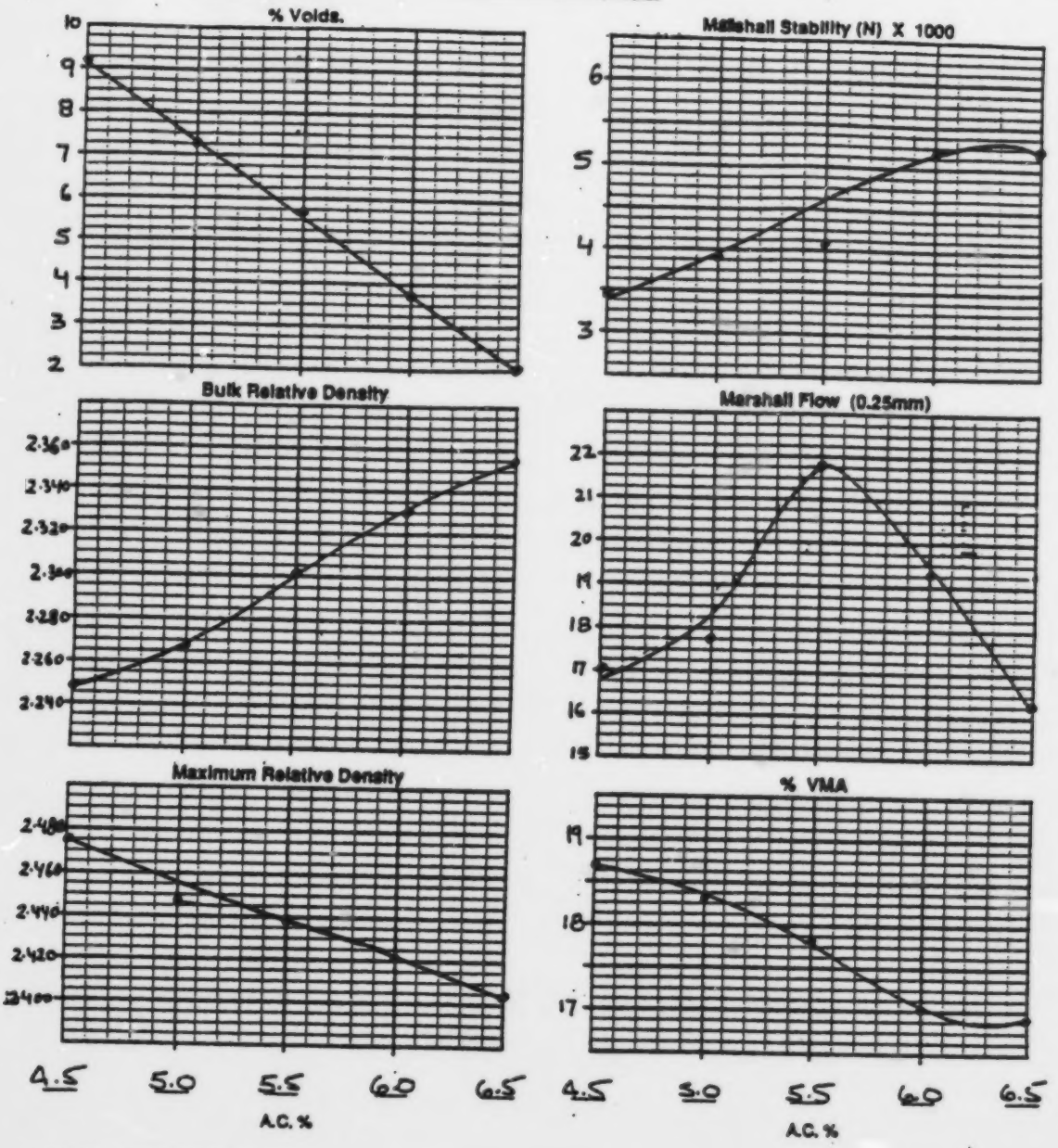
REMARKS:

REVIEWED BY: _____ (MTO) DATE: _____

FIGURE 4

Trow BITUMINOUS MIX DESIGN: Contract No. 90-800 Mix Type / Use HL 4 / SURFACE COUR:

Lab Mix No. HL 4 RUB



VISUAL OBSERVATIONS: _____

FIGURE 5

TABLE 4
COMPARISON OF WORST CASE VALUES COMBINED WITH EMISSION RATES TO STANDARDS USING ONTARIO MINISTRY OF THE ENVIRONMENT AIR DISPERSION MODELS

COMPOUND	MAXIMUM EMISSION RATE		MAXIMUM GROUND LEVEL CONCENTRATION				MAXIMUM CONCENTRATION AT POI IDENTIFIED IN CERTIFICATE OF APPROVAL APPLICATION				ONTARIO 0.5 hr POI "STANDARD"	
	g/sec *	g/sec *	µg/m³ *	%	µg/m³ *	%	µg/m³ *	%	µg/m³ *	%	µg/m³ *	
	HL 4	RUBBER ASPHALT	HL4	% OF STND	RUBBER ASPHALT	% OF STND	HL 4	% OF STND	RUBBER ASPHALT	% OF STND		
SUSPENDED PARTICULATE	1.92	5.49	133.33	133	381.24	381	141.77	142	405.37	405	100	FOR d<44 µm
PARTICULATE CONCENTRATION IN STACK GAS	0.32	0.91		138		395					0.2[f]	
CONTINUOUSLY ANALYZED 1/2 HOUR AVERAGE MAXIMUMS												
NITROGEN OXIDES	1.18	0.78	82	16	54	11	87	17	58	12	500	
SULPHUR DIOXIDE	0.39	0.39	27	3	27	3	29	3	29	3	830	
CARBON MONOXIDE	16.43	3.97	1141	19	276	5	1213	20	293	5	6000	
TOTAL REDUCED SULPHUR	0.09	0.04	6	16	3	7	7	17	3	7	40	
TOTAL DIOXINS	22.40[a]	9.10[a]	1.56[d]	0.35	0.63[d]	0.14	1.65[d]	0.37	0.67[d]	0.15	450[d]	
TOTAL FURANS	401.80[a]	3.10[a]	27.90[d]		0.22[d]		29.67[d]		0.23[d]			
DIOXINS AND FURANS			0.065	6.5	0.002	0.2	0.070	7.0	0.002	0.2	1	ratio calculation
TOTAL PCB's	5.071700[b]	2.284400[b]	352.19[c]	78	158.63[c]	35	374.48[c]	83	168.67[c]	37	450[c]	
BENZO-A-PYRENE	0.007674[b]	0.013660[b]	0.53[c]	16	0.95[c]	29	0.57[c]	17	1.01[c]	31	3.3[c]	
TOLUENE	0.027665	0.015299	1.92	0.10	1.06	0.05	2.04	0.10	1.13	0.06	2000	
ETHYLBENZENE	0.015760	0.002692	1.09	0.027	0.19	0.005	1.16	0.029	0.20	0.005	4000	
XYLENES	0.092928	0.022801	6.45	0.28	1.58	0.07	6.86	0.30	1.68	0.07	2300	
STYRENE	0.009995	0.007458	0.69	0.17	0.52	0.13	0.74	0.18	0.55	0.14	400	
BENZENE (total amounts emitted by this project)	0.009556	0.008526	1324.39[e]	166	1181.69[e]	148	38.5 hours for HL4 mix 38.5 hours for rubberized program				800[e]	total per year

POI = Point of Impingement; Concentrations at POI's derived using worst case from Ontario Ministry of the Environment Regulation 308 Dispersion Models
"STANDARD" = Ontario Ministry of the Environment Standard, Tentative Standard Guideline, Provisional Guideline (May 1990 List)
g/Rm³ = result in g/m³ at reference temperature and pressure
* = except as noted
a = result in ng/sec
b = result in mg/sec
c = result in ng/m³
d = result in pg/m³
e = result in grams
f = result in g/Rm³

Table 5 Process Water Maximum Analysis Results Compared With Water Quality Objectives and Ontario Model Sewer Use Bylaw

Compound	Maximum Level Measured	PWQO	Model Sewer Use Guidelines
Aluminum mg/1	6.14	0.1	50
Cadmium mg/1	<0.005	0.00015	1
Cobalt mg/1	0.05		5
Chromium mg/1	<0.01	0.1	5
Copper mg/1	0.08	0.005	3
Iron mg/1	13.3	0.3	50
Lead mg/1	0.06	0.005	5
Manganese mg/1	6.79	0.05 ODWO	5 ***
Molybdenum	0.3		5
Nickel mg/1	0.07	0.025	3
Phosphorus mg/1	1.1	0.01	10
Silver mg/1	<0.005	0.0001	5
Strontium mg/1	2.58	0.007	
Titanium mg/1	0.038		5
Vanadium mg/1	0.014	0.007	5
Zinc mg/1	0.16	0.016	3
Toluene µg/1	0.7	0.4	
Phenol µg/1	96.1	5	
2, 4-Dimethylphenol µg/1	15.8	10.5	
Phenols mg/1	0.575	0.001	1
Total Kjeldahl Nitrogen mg/1	31		100
Ammonia expressed as Nitrogen mg/1	10.1	0.016	
Ammonia mg/1	12.26	0.02	
Organic Nitrogen mg/1	20.9	0.15 ODWO	

PWQO - Provincial Water Quality Objective
ODWO - Ontario Drinking Water Objective - maximum desirable concentration
*** - Only identified exceedance of sewer use guideline

Table 6 Comparison of Highest Airborne Worker Exposure Levels to Ontario Regulatory Guidelines

Contaminant	Maximum Exposure Level Measured mg/m3	Time Weighted Average Exposure Level mg/m3
Benzene	<0.1	16
Toluene	0.1	376
Ethyl Benzene	<0.1	435
Xylenes (sum of isomers)	<0.1	435
Styrene	<0.2	213
Napthalene	<0.3	52
Total Particulate	15.9	10
Aluminum, water soluble	0.047	2.0
Barium	0.0013	0.5
Chromium II and III total Cr measured	0.0016	0.5
Cobalt	<0.0007	0.05
Copper	0.0019	1.0
Iron, water soluble	0.0737	1.0
Lead	0.0023	0.15
Magnesium as MgO	0.052	10.0
Nickel, acid digestate	<0.001	1.0
Titanium, as TiO2	0.0251	10.0
Vanadium, as V2O5 respirable	0.0438	0.05
Zinc as ZnO	0.3738	10.0
Coal Tar Pitch Volatiles	0.13	0.2
Asphalt Fume for comparison purposes		5.0